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standing, while those peculiarities which distinguish them from each other are in most cases of later origin. If, then, we make a reciprocal cross, that is, if we select two allied species or varieties and cross the male of one with the female of the other, and then reverse the process, using the female of the first and the male of the second, we should expect in most cases to find a difference in the offspring. Where the male of species A is crossed with the female of species B, we should expect the offspring to inherit from its mother the characteristics common to both parents, and from the father some of the distinctive marks of the species or variety A. In the second case we should expect it to unite some of the features of the form B to those peculiar to the genus. To take a special case; if we cross a stallion with a female ass we should expect, according to our hypothesis, to find that the offspring exhibited the characteristics of the Equidæ, together with some of the distinctive features of the horse, while we should expect to find that the offspring of the jackass and the mare united some of the specific features of the ass to those common to both parents. It is needless to say that this experiment has been tried thousands of times with a uniform result which agrees perfectly with the demands of our hypothesis. In some cases the result of reciprocal crosses seems to directly oppose our conclusions, but the difficulty is in many instances only apparent. A species sometimes differs from its allies, not in having acquired new characteristics, but by reversion or arrest, and such a species will transmit its distinctive features through the female rather than through the male. Thus the Niata cattle, which seem to be a reversion to an extinct form, are more prepotent over other varieties through the female than through the male.

TRACES OF A VOICE IN FISHES.

BY CHARLES C. ABBOTT, M. D.

IF speech be but the means of communicating emotions or intentions to other beings, even invertebrate animals possess faculties of the same nature. We see insects, such as ants, which live in so-called communities, carrying out elaborately preconcerted warlike undertakings and attacks. A beetle which in rolling the ball of dung inclosing its egg has allowed it to slip into a hole from which it is unable to extricate it, flies away, to return in a short time with a number of assistants suffi-

cient to push the ball up the sides of the declivity by coöperation of labor. These creatures must, therefore, unquestionably possess some means of communicating with each other concerning this combination. It requires no long observation of our song birds to distinguish the different tones by which they warn their young of danger, or call them to feed, or by which they attract each other to pair. These animals, therefore, have at their control a certain number of signals which are quite adequate to procure for them some few of the wants of their life, and these signals, as far as we can at present guess, have been acquired and inherited in the same manner as were their instincts." (Peschel.)

Although we are all familiar with the lazy drum-fish of our sea-coast, — and some may have heard those grunting sounds that have given this species its common name, — the little fishes of our inland brooks and more pretentious denizens of our rivers are looked upon as voiceless creatures; that if indeed they have ideas, they must express them entirely by movements, not of one portion, but by their whole bodies. But, in fact, the conditions that obtain among insects and birds, as detailed in our quotation from Dr. Peschel,¹ are, in a measure, applicable to our fishes; at least, in the several years of my studies of the habits of our more common species, I have concluded that certain sounds made by these fishes are really vocal efforts, and that their utterance is for the purpose of expressing an idea to others of their kind; and furthermore, that these sounds are closely connected with their breeding habits, although I have heard these same sounds at other seasons.

Probably no one has failed to notice the brilliant colors of the restless red-fin, as it darts to and fro through the clear waters of a crystal brook, or the crimson fins of the silvery roach, that ere summer has passed, pale to dull yellow and lose all their glow; but while with all our fishes there is at one time of the year a deepening of every tint, this is in no wise comparable to the gorgeous hues nature has vouchsafed to a certain few. My studies of the habits of these common fishes have suggested that the bright colors of spring, which are analogous to the breeding plumage of male birds, might possibly bear the same relationship to vocal sounds that the songs and plumage of birds bear to each other. With some exceptions, our finest songsters are dull-colored birds. Have our plainer-tinted fishes a compensation for this attraction of color in the ability to utter sounds?

¹ The Races of Man, page 101. By Oscar Peschel. D. Appleton & Co. 1876.

After several summers spent in observing the breeding habits of these common fishes, I have been able to form two tables, referring to the breeding habits and the relationship of color and supposed voice thereto, of sixteen species of fresh-water fishes. In the first of these, I have simply separated them into bright, and dull colored species; the bright coloration referring to the breeding dress or spring coloration. In the second list, I have separated them according to their supposed vocal powers, and absence of such powers; and it will be seen on comparison that a combination of voice and color does not occur.

TABLE I.¹

<i>Brilliant Colors.</i>	<i>Dull or Silvery.</i>
Yellow perch.	Spineless perch.
Common sunfish.	Mud sunfish.
Banded sunfish.	Gizzard shad.
Red-fin.	Mullet.
	Eel.
	Cat-fish.
	Lamprey.

TABLE II.

<i>Supposed Vocal Power.</i>	<i>Voiceless.</i>
Spineless perch.	Yellow perch.
Mud sunfish.	Common sunfish.
Gizzard shad.	Red-tailed sunfish.
Mullet.	Banded sunfish.
Lamprey.	Chub.
Cat-fish.	Roach.
Eel.	Red-fin.
	Pike.
	Bill-fish.

We have here four species enumerated that are brilliantly colored, and seven that are dull or silvery; and of the former, none are believed to have any voice proper, while of the seven of the right-hand column, all are believed to be so endowed. In the right-hand column of Table II., it will be noticed that the "voiceless" species include the four highly colored fishes and five others, all of silvery tints, which I have carefully studied, that have no habit, so far as traceable, which would separate them from the list of species without voice. We can scarcely then avoid the conclusion, that with fishes as with birds the brilliantly colored males, as a rule, are mostly, if not wholly, dependent on their hues to attract the females in the amatory season.

Those who may be familiar with the common chub (*Semotilus*

¹ I have purposely omitted the sturgeon from the list of plainly colored fishes, as I desire to make a separate study of the habits of this fish.

corporalis) will doubtless urge as an exception, that the peculiar grunting sounds made by this fish when taken from the water entitle it to a place among the list of species supposed to have a voice; but I have not been able to detect this sound except at such a time, and as the fish is then out of water and struggling, it may be involuntary. On the other hand the deep bronze and golden-green tints of the fresh-water bass, or "mud sunfish" (*Acantharcus pomotis*), may be maintained to be a case of high coloration, and a sexual attraction; and the same might be said of the land-locked gizzard shad (*Dorosoma cepedianum*), but the former of these has been most frequently of all fishes observed by me to voluntarily utter sounds when confined in an aquarium; still I doubt not there are many exceptions, and one great objection, and at first it seems a fatal one, to the suggestions I have made is that there probably are so very many exceptions to the supposed rule. But to refer again to the case of birds. Assuming the correctness of evolution, as I do, then we need go back but a very short period in geological time to see the numerous species of our birds reduced to single representatives of each genus, and even far fewer of so-called genera. With the avifauna thus simplified, the differences that now exist between our sombre-hued songsters and gayly colored songless birds, were doubtless more marked; and might not this be held true of our fishes also? The vast influence brought to bear upon all animals by their surroundings and the increasing struggle for existence has evolved in later times and is evolving innumerable variations in the forms of life of the present time; and these changes have in so great a measure obscured the conditions that once characterized both our birds and fishes, in the matter of the relationship of voice and color, that what I believe to have been once a well-marked feature of animal life is now traced with difficulty. Nevertheless, the many instances of apparent voice that I have noticed, and their relationship as to color, induce me to believe that what is now scarcely a rule, perhaps, as obtaining among fishes, was once a law that governed them.

In studying these same fishes in another phase of their habits, we see that while all of the species enumerated are active throughout the day, it cannot be questioned that some of them are far more active at night, and shun, if undisturbed, the glare of mid-day sunshine. These partially, if not strictly nocturnal species are those that I have considered as having the power to give out or utter a truly vocal sound, and they are the more plainly

colored species. The brilliant tints being of little or no use by night necessitates the diurnal habits of those fishes possessing them, while the nocturnal species, with a voice as a compensation for color, are enabled to carry on a courtship in part by its aid which would be of little or no use during the day.

Having given an outline of the conclusions reached, as to the supposed relationship of voice and color among certain fishes, let us consider in detail the characteristic habits of two of the best-known and most widely differing species of the list given. As representing the voiceless but highly tinted fishes, let us take the common sunfish (*Pomotis vulgaris*), and on the other hand the equally familiar cat-fish (*Amiurus lynx*) as an instance of a fish that has the power of uttering a sound, — that has the rudiments of a voice.

With the bursting of the leaf-buds and disappearance of the ice from the shady nooks of our quiet inland ponds, the gayly tinted sunfish that all winter long has been lazily loafing in the deeper waters of his old-time haunts dons not another scaly coat, indeed, but so renews and polishes the old that he might well pass for another of his kind; and, coming boldly to the sunny shallows, darts restlessly about, admiring himself, I doubt not, but to his greater satisfaction being admired by others, and before the flowers of May have faded has gotten himself a mate. But the courtship of this gaudy fish has been no easy matter. Hundreds of his kind, as bright as he, have, like him, striven by the hour to clear the field of every rival; and the clear waters are often turbid with sand and grass torn from the bed of the stream, as the older males chase each other from point to point, endeavoring by a successful snap to rob each other of a fin. No courtship battles among birds are more earnestly fought; and as the bird with bedraggled feathers is wise enough to withdraw from the contest and quietly seek a mate when his soiled plumage is in part restored, so the sunfish with mangled fins retires from the nesting grounds. But not a sound has been made by these excited fishes, except that of the rippling water when cut by their spiny fins as they chanced to reach above the surface. Never, when for a moment quiet, have we chanced to see the delicate chain of silvery bubbles that escape from the mouth of the bass (mud sunfish) when, shall we say, calling to its mate? At night, I believe, the sunfish rests from his labors. I have not been able to detect any continuance of his spring-time vivacity after sunset, and am led to

conclude that his sole dependence in securing a mate is in his brilliant coloring.

What a contrast is presented in the lazy, dull-colored cat-fish that slowly wanders over the muddy bed of the stream, if perchance he is moving about at all, during the day! Not a motion can be detected that is not referable, without doubt, to so prosaic a matter as the search for food. If a dozen or more come together, it is but to hunt in concert, and nothing of the nature of a contest is to be seen. But after sunset, every one of their kind becomes suddenly more animated; there is a marked restlessness in their every movement, as they congregate in large numbers in some limited area. At such a time, their presence is to be detected not only by the aid of "submarine lanterns" and all the troublesome helps that one must employ to study fishes at night; there is an opportunity given to use one's ears as well as eyes, and by careful, patient waiting we may hear, even from the deeper waters, a gentle humming sound that, if noticed at all, by most people would be referred to the insect life teeming about them. If, knowing or suspecting the true origin of this gentle murmur, we can, without alarming the fish, float our boat carefully to a point directly above them, we will find that scores of chains of little air bubbles are rising to the surface; and as the sound increases or dies away, in proportion to the abundance or absence of the bubbles, it is safe to refer the sound to the fishes that by voluntarily expelling the air from their bodies produce the murmurs we have mentioned. But, thanks to the aquarium, by its aid we have confirmed it.

I have not the space, here, to enumerate all the circumstances connected with these voluntary emissions of sounds by certain of our fishes, seven species of which I have particularly mentioned. Brief references to the others must here suffice. Concerning the first mentioned of our little list, the spineless perch, or "pirate" (*Aphrodederus sayanus*): my knowledge of its habits have been mostly derived from aquarial studies, but although the diminutive size of the very largest specimens obtained—a little over four inches in length—rendered it very difficult to be certain that sound accompanied the expulsion of air from their bodies, I am almost sure I detected it, and the actions generally of the fish were such as to render it in a high degree probable that there was a sound heard by the female fishes of their kind.

Of the percoid, that I have here called the "mud sunfish"

(*Acantharcus pomotis*), there is no doubt. Not only in the muddy brooks where it is mostly found, but also when confined in an aquarium, this fish will utter at times a deep grunting sound that cannot be mistaken. That it is voluntary, too, is evident from the quick, nervous movement of the whole body, and wide distention of the gill-covers that accompanies the sound. These sounds and those of the cat-fish first called my attention to the subject of voluntary production of sound or "voice" in fishes. Like the spineless perch, this sunfish is, I think, strictly nocturnal in its habits, and, from aquarial observations I am led to believe, chooses a mate, and accompanies her to the nest for ovipositing only at night.

Of that interesting fish, the land-locked "gizzard shad" (*Dorosoma cepedianum*), my observations have led to the detection of a very audible, whirring sound, not unlike the deeper notes of a coarse string of an æolian harp. Those who may have noticed, at times, the vibrating thrill that arises from the wind passing over a number of telegraph wires, will have heard a sound nearly identical. I judge that both sexes utter this sound in concert; but it may be that during the early spring the sexes separate, to come together again some few weeks later, when spawning commences, and, in such a case, that only the males were "singing." We find, especially in the herring tribe, that the sexes migrate separately; but in the case of the gizzard shad, when land-locked, as there could be no migration, this separation probably does not occur.

The chub-sucker or mullet (*Moxostoma oblongum*) is another example of those dull-colored, nocturnal fishes that frequent streams with muddy beds thickly overgrown with water plants, and which have the power of audibly forcing air from their bodies. In April, with a noticeable deepening of their coloration, there is increased activity in every movement, and, wholly unlike their actions by day, at night they swim quite near the surface, and utter a single prolonged note accompanied by a discharge of air-bubbles. They appear to project their jaws just above the water, and force the air from beneath their gill-covers immediately below the surface, as there are two parallel streams of bubbles. When seen in the moonlight, these bubbles appear like minute silver beads. Swimming in this way, the mullet will often proceed a hundred yards, uttering their peculiar "call" four or five times while passing over that distance.

In the lamprey (*Petromyzon nigricans*) we have a semi-noc-

turnal species that I have had but few opportunities of observing closely, as it frequents rapidly running water and spends much the greater portion of its time under flat stones. On two occasions I have had opportunities of watching them, when paired, and thought that they uttered a peculiar sound, quite dissimilar to that of any other fish note I had heard, but it was unaccompanied so far as I could determine by a chain of air bubbles rising to the surface, such as always are seen to accompany the notes uttered by the chub-sucker or cat-fish. This same noise, or one very similar, was made by them when captured and taken from the water, and, in both instances, may have been involuntary. From their peculiar anatomy, they are an exceedingly interesting species with reference to the subject of voice so-called; and I regret that my experience when keeping them in an aquarium did not confirm my suspicions when studying them in their proper habitat. When in an aquarium, I occasionally heard a prolonged buzzing sound that had many of the characteristics of what I have considered voice in other species, but it was too monotonous and protracted to be considered a voluntarily produced sound or vocal effort. If the more voice-like sounds heard, as mentioned, are characteristic of their breeding season, then it probably is strictly a "love call," and certainly, when paired, these fishes are exceedingly amorous.

In all the instances so far mentioned of voluntarily expressed sounds or utterances of fishes, they have been referred to in connection with their ordinary breeding habits; not that they are never heard at other times, but because these "calls" or "songs," or whatever they should be considered, are a marked feature of that season. In our common eel (*Anguilla acutiros-tris*) we have an instance of a fish possessing unmistakable evidences of voice, yet which may be said to have no breeding season, at least when found far inland. Without inquiring into the still doubtfully determined breeding habits of the eel, it is sufficient here to say, that in countless thousands they pass from the sea up our rivers, and so, far inland through the most insignificant brooks, and certainly often reach isolated ponds. From these ponds they seldom escape. Here they grow to a large size, and live to a great age; yet summer after summer passes without any indication of their breeding. No species of fresh-water fish is more strictly nocturnal in its habits, and none are so easily studied, inasmuch as at night they are not only very active but keep continually near the surface. In the matter of voice, eels

utter a more distinctly musical sound than any other of those I have mentioned. It is a single note, frequently repeated, and has a slightly metallic resonance. I have heard this sound only at night, and never when the animal is taken from the water by day, as when captured by a hook, so that I presume it is not involuntary. When a large number of eels are congregated in a small space, as when feeding on some decayed animal, I have heard this note very frequently repeated, and from the volume of sound I judge that large eels utter only a note that is distinctly audible. It is well known that this fish occasionally leaves the water voluntarily and wanders a considerable distance to other streams or ponds; and when through protracted droughts a pond becomes quite dry, while other fishes perish, the eels suffer little inconvenience, as, snake-like, they crawl at night over a considerable stretch of land, guided by some undetermined instinct to the nearest water. At such a time the eel will occasionally utter this same clear note, especially if surprised. From what I have been able to determine concerning these overland journeys of the eel, they are undertaken only when the grass is well moistened with dew, and a surface of any extent devoid of thick vegetation is an effectual barrier to their progress. I would add, that I have noticed when "bobbing" for eels, namely, catching them without injury to their mouths, that when squirming about the bottom of the boat they not unfrequently utter this same sound, not inaptly compared, perhaps, to the faint squeak of a mouse.

I have given one instance, that of the common Pomotis, of a fish that is strictly a diurnal species, of bright coloration, and that passes through the various phases of courtship and nidification without uttering a sound; and on the other hand, more or less in detail, referred to several other fishes that are all of dull coloration, are nocturnal in their habits, and, whether voluntarily or not, certainly at times do utter sounds. They cannot be considered as simply making a noise, this arising from the unavoidable result of certain muscular movements. The action that produces the sound, on the contrary, I have been led to believe is one intentionally performed that the sound may result, and the fish has a distinct purpose in view in the latter, it being a call to others of its kind, which is responded to by the approach of those hearing it and for whom it was intended.

When we carefully study the entire ichthyic fauna of a given locality, say of a single small stream, as I have done in this case,

we shall undoubtedly find some exceptions to this supposed rule of dissociation of coloration and voice; but these may be less in number than appear to us, when we consider how great a number of diminutive species are found in every stream, that cannot be determined in which class they should be placed; for while many are dull colored and doubtless possess voice (the well-known mud minnow, *Melanura limi*, is an excellent example), this is too faint a sound for us to detect; but from the fact that this peculiarity can be determined in some of the larger species, it is not improbable that in earlier geological eras fishes generally were of sombre tints, and possessed more decided vocal powers than at present; and that in the subsequent differentiation of genera and species, color was more and more evolved as a generic character, and voice became proportionately less a feature of our fishes, but was retained in some and reappears in still stronger development in those connecting links between fishes and the higher vertebrates, culminating in the batrachians, where it is perfected by the presence of a larynx.

In conclusion, it is well to quote briefly from an author who has most scientifically discussed this same subject.¹

He writes: "Not only is there every reason to believe that the majority of sounds produced by fishes are not casual utterances, but are truly voluntary, but there is among such as give vent to them a most remarkable development of the organs of hearing in all essential particulars, for example, in the semi-circular canals, otoliths, and nerves, correlative with the degree of perfection of the instrument. Further than this, as the sounds generally excel in frequency and intensity at the breeding season, it will not be unreasonable to regard them, — granting, as we do, that the chirp of the cricket and the croak of the frog is each in its way an alluring serenade, — as nuptial hymns, or, to use language ascribed to Plutarch, as 'deafening epithalamia.' More than this; seeing that the carp, and others of the same family, have given unmistakable proofs of their aptitude to receive some rudiments of education, and in particular to perceive certain sounds, it can yet be possible that the moral admonitions of a St. Anthony of Padua — by many still regarded as a work of supererogation — may, no less than the amorous twang of the vesical zither, after all not have fallen upon totally deaf ears."

¹ Songs of Fishes. By John C. Galton. Popular Science Review, October, 1874. (Consult also Recherches sur les Bruits et Sons expressifs que sont entendre les Poissons d'Europe, par M. Dufossé. (Annales des Sciences Naturelles. Tom. xix., xx., 1874.) With many illustrations. This article doubtless inspired the excellent one by Mr. Galton. — EDITOR AMERICAN NATURALIST.)